

STUDIES IN THE GENUS *FRAXINUS*

I. A PRELIMINARY KEY TO WINTER TWIGS FOR THE SECTIONS MELIOIDES AND BUMELIOIDES.

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With plates 87-89 and two text figures

THIS STUDY represents a preliminary attempt to provide a key for the identification of certain species of *Fraxinus* in the winter condition. The key is a preliminary one in two respects. In the first place, it is limited to those species of the sections *Melioides* and *Bumelioides* of which living material was available for study. In the second place, like any key based entirely on dormant twigs, it needs extensive checking in the field. For this reason, the author will be grateful if those who use the key and the descriptions will bring any inaccuracies to his attention.

Wherever possible collections were made at several localities, and from many trees. In the case of exotic species grown only at the Arnold Arboretum, it was often necessary to limit the study to one or two trees, supplementing the information thus gathered with such evidence as could be obtained from herbarium material.

The following species and varieties were included in the study. The numbers in parenthesis refer to the number of localities at which collections were made, exclusive of herbarium material.

SECTION MELIOIDES

Fraxinus pennsylvanica Marsh. (3).“ *biltmoreana* Beadle (2).“ *profunda* Bush (2).“ *oregona* Nutt. (1).“ *pennsylvanica* var. *lanceolata* Sarg. (3).“ *americana* L. (7).“ *texensis* Sarg. (1).

SECTION BUMELIOIDES

Fraxinus syriaca Boiss. (1).“ *potamophila* Herd. (1).“ *quadrangulata* Michx. (3).“ *mandshurica* Rupr. (1).“ *holotricha* Koehne (1).“ *oxycarpa* Willd. (1).“ *excelsior* L. (1).“ *nigra* Marsh. (4).

A twig of *Fraxinus* in the winter condition (Fig. 1) presents a number of features of diagnostic value: terminal bud, terminal bud scales, terminal bud scale scars, lateral buds, leaf scars, bundle scars, lenticels, bark, pubescence.

TERMINAL BUD: The terminal bud varies in shape from obtuse as in *F. americana* to acute as in *F. biltmoreana*. The terminal bud is of a brown color which ranges from nearly black in *F. excelsior* to a light rusty brown in *F. pennsylvanica*. In all cases, except that of *F. nigra*, the terminal bud is closely flanked by a pair of lateral buds. In *F. nigra* the terminal bud is solitary, that is, it is raised above the distal pair of laterals.

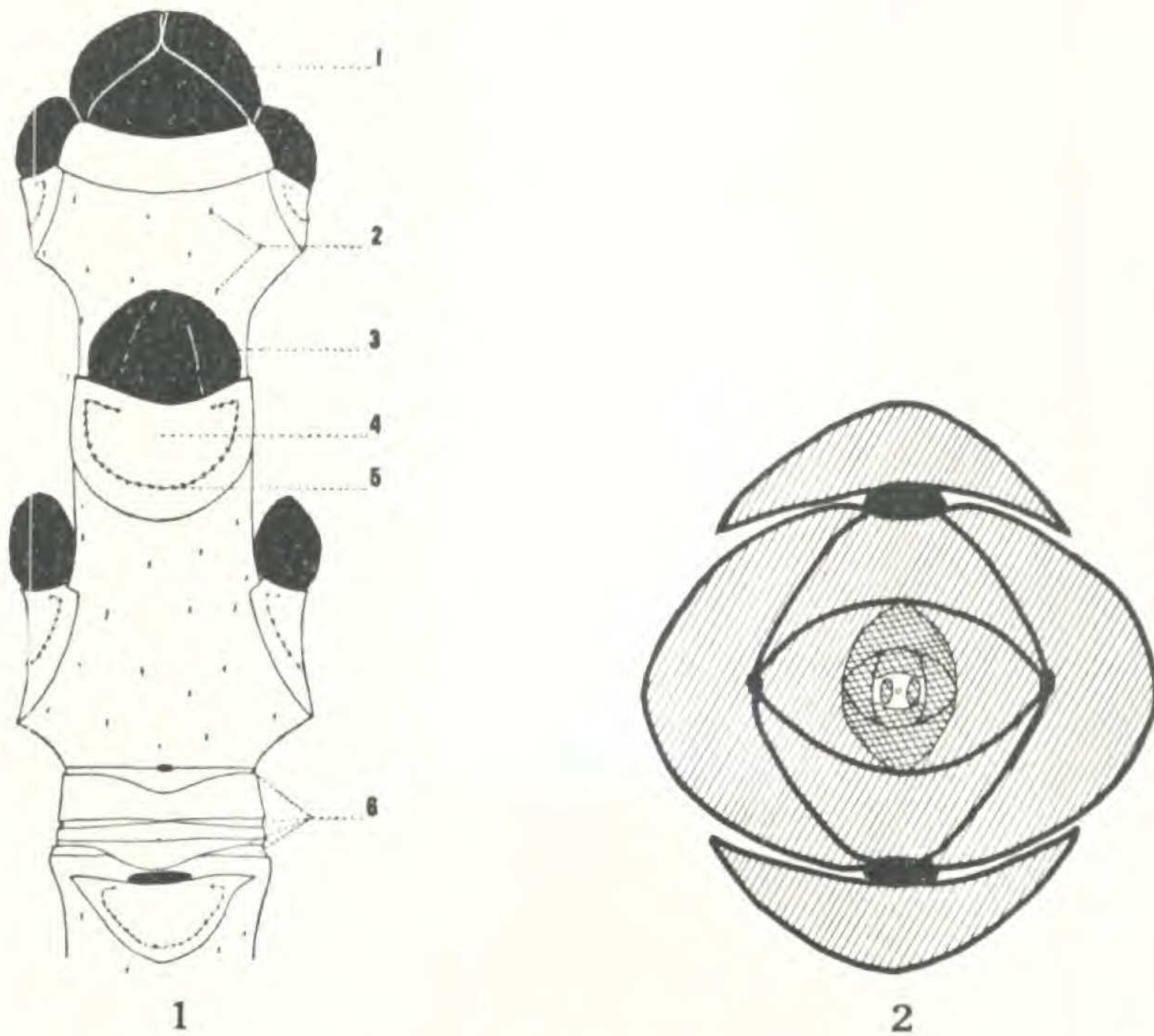


FIGURE 1. Dormant twig of FRAXINUS (somewhat diagrammatic). 1, terminal bud; 2, lenticels; 3, lateral bud; 4, leaf scar; 5, bundle scars; 6, terminal bud scale scars.

FIGURE 2. Cross section of a terminal bud of FRAXINUS. Bud scales are shaded with diagonal lines, leaves are cross hatched.

TERMINAL BUD SCALES: The number of terminal bud scales varies from two to four pairs, although it is generally consistent within a given species. The scales are arranged decussately as shown in Fig. 2. The individual scales vary in shape from ovate, apiculate, flat, to lanceolate, pinnate, and thickened on the back. They also may be tightly appressed (*F. americana*) or loose (*F. mandshurica*). A character of considerable systematic importance is the development of the foliar tip of the terminal bud scales. Though it is subject to considerable variation within the species, it remains as one of the best

guides to winter identification. The terminal bud scales are always pubescent, varying somewhat in degree. In *F. quadrangulata*, they are hoary tomentose, while at the other extreme are such species as *F. americana* and *F. texensis* in which the pubescence is reduced to a minute scurfy puberulence. The inner scales of *F. syriaca* are hoary tomentose and protrude from beneath the outer scales. The outer scales of *F. biltmoreana* are woolly along their midrib.

TERMINAL BUD SCALE SCARS: The number of terminal bud scales can be more readily obtained from the scars than from the bud itself. This number is a valuable aid in the identification of the species. For example, *F. americana* has four pairs; *F. nigra* and *F. quadrangulata* have three pairs; while *F. oxycarpa* has two pairs.

LATERAL BUDS: The number of leaf pairs per year varies from three or even two pairs to as high as twelve pairs. Ordinarily they are arranged oppositely except in *F. syriaca* where they are usually whorled. The whorled arrangement may occur in any of the species. It was found occasionally in *F. potamophila* and *F. oxycarpa*, and in a single specimen of *F. americana*.

The lateral buds of *Fraxinus* may be divergent or convergent; angular or rounded. Divergent buds are those which stand at a sharp angle to the twig rather than being closely pressed and nearly parallel with it. Angular buds are those which tend to be diamond shaped rather than circular in cross section.

LEAF SCARS: The leaf scars range from semiorbicular or crescent shaped (*F. americana*) to semicircular (*F. pennsylvanica*) to oblong or obconic (*F. profunda*) to orbicular (*F. nigra*) to obcordate (*F. biltmoreana*). The leaf scars may be raised from the surface of the twig as in *F. mandshurica* or flat as in *F. pennsylvanica*.

The upper edge of the leaf scar protrudes, forming a shelf which sheathes in varying degree the base of its lateral bud in the following species; *F. oxycarpa*, *F. nigra*, *F. pennsylvanica*, *F. pennsylvanica* var. *lanceolata*, *F. excelsior*, *F. oregona*, *F. profunda*, *F. quadrangulata*, *F. mandshurica*, *F. holotricha*, *F. biltmoreana* and *F. texensis*. This feature reaches its maximum development in *F. nigra*. Pubescence appears on the extreme upper edge of this shelf in the following species; *F. pennsylvanica* var. *lanceolata*, *F. biltmoreana*, *F. holotricha* and *F. mandshurica*. Generally the surface of the scar is flat, but the conspicuous shelf in *F. nigra* gives it a concave appearance while the raised bundle scars of *F. profunda* make the scar appear convex.

The leaf scars of *F. pennsylvanica* and *F. oregona* are often a darker color below the bundle scars than above them. That is, the lower portion may be greenish grey (*F. oregona*) or dull brick-red (*F.*

pennsylvanica). The upper part of the scar is always a dull light buff. The angle which the leaf scar makes with the twig is from 45° (*F. americana*) to nearly parallel with the twig surface (*F. nigra*).

BUNDLE SCARS: The bundle scars of *Fraxinus* are confluent, forming a slightly raised line above the surface of the leaf scar. This is often very pronounced in *F. profunda*. The line parallels the margin of the leaf scar, even turning in at its upper edge. The relative position of the line varies, that is, it is nearer the margin than the center of the leaf scar in *F. americana* while in *F. quadrangulata* this condition is reversed. Due to the confluence of the bundle scars it is difficult to ascertain their number which seems to vary from twenty to thirty in each leaf scar.

LENTICELS: In all the species of *Fraxinus* examined, the lenticels are conspicuous, more or less elongated, light colored dots. They are scattered over the twig except in *F. quadrangulata* where often they tend to be grouped beneath the leaf scar.

BARK: The outer bark of the twigs is of little diagnostic value. The bark of *F. oregona* has a greenish hue beneath the pubescence, whereas that of *F. americana* is dark shiny maroon often spotted with a glaucous bloom.

The inner bark in the Melioides section is shiny brick-red while that of the Bumelioides section is dull light buff except in the case of *F. oregona* which resembles the Melioides section. The internodes of *F. quadrangulata* are more or less four-angled due to the development of corky ridges.

PUBESCENCE: The degree of pubescence varies from completely glabrous (*F. americana*) to tomentose (*F. biltmoreana*). The pubescence of *F. pennsylvanica* may persist for two or three seasons or disappear after the first summer, while that of *F. biltmoreana* usually does not persist after the first summer.

The pubescence of *F. quadrangulata* and *F. oregona* is more dense at the nodes than at any other part of the twig. The twig of *F. nigra* is glabrous except just below the terminal bud where there are many small dots of scurfy-pubescence.

KEY TO SECTIONS

- A. Terminal bud scales entire; inner bark brick-red (except in *F. oregona*)MELIOIDES
- AA. Terminal bud scales foliar; inner bark light buff....BUMELIOIDES

Section MELIOIDES

- A. Branchlets pubescent.
- B. Twigs tomentose throughout; buds light brown.

- C. Diameter of terminal bud conspicuously smaller than that of twig; upper edge of leaf scars not lined with hairs.1. *F. pennsylvanica*
- CC. Diameter of terminal bud equal to or larger than that of twig; upper edge of leaf scars lined with hairs2. *F. biltmoreana*
- BB. Twigs unevenly tomentose; buds dark brown.
 - C. Terminal bud scales usually in three pairs; outer terminal bud scales usually sharply truncate.
 - 3. *F. profunda*
 - CC. Terminal bud scales usually in four pairs; outer terminal bud scales not truncate.4. *F. oregona*
- AA. Branchlets glabrous.
 - B. Terminal bud acute.5. *F. pennsylvanica* var. *lanceolata*
- BB. Terminal bud obtuse.
 - C. Terminal bud scales usually in four pairs; base of lateral buds not sheathed.6. *F. americana*
 - CC. Terminal bud scales usually in three pairs; base of lateral buds sheathed.7. *F. texensis*

Section BUMELIOIDES

- A. Twigs shiny green; lateral buds keeled, not sheathed at base.
 - B. Inner lateral bud scales visible, light wooly pubescent; upper edge of leaf scars protruding; bundle scars above center of leaf scar; leaves always whorled.8. *F. syriaca*
- BB. Inner lateral bud scales not visible; upper edge of leaf scars not protruding; bundle scars bisecting leaf scar; leaves seldom whorled.9. *F. potamophila*
- AA. Twigs not shiny green; lateral buds not keeled, sheathed at base.
 - B. Twigs with more or less quadrangular internodes.
 - C. Lenticels often grouped below leaf scars; lower edge of leaf scars often flattened; twigs short rufous to scurfy-pubescent; buds wooly-pubescent.
 - 10. *F. quadrangulata*
 - CC. Lenticels scattered; lower edge of leaf scars rounded; twigs glabrous; buds scurfy-pubescent.
 - 11. *F. mandshurica*
 - BB. Twigs with rounded internodes.
 - C. Twigs pubescent; terminal bud scales usually in three pairs.12. *F. holotricha*
 - CC. Twigs glabrous; terminal bud scales usually in two or three pairs.
 - D. Terminal bud scales in two pairs; twigs flattened at nodes13. *F. oxycarpa*
 - DD. Terminal bud scales usually in three pairs; twigs rounded at nodes.
 - E. Terminal bud flanked, obtuse; upper edge of leaf scars protruding slightly.14. *F. excelsior*
 - EE. Terminal bud solitary, acute; upper edge of leaf scars protruding sharply.15. *F. nigra*

DESCRIPTION OF SPECIES

1. **Fraxinus pennsylvanica** Marsh. Plate 87, Fig. 1.

Terminal bud acute, flanked or nearly so; three pairs of scales, outer pair truncate, rufous-tomentose, usually rusty-brown. Lateral buds rounded. Leaf scars semicircular, parallel with twig or nearly so, upper edge protruding slightly. Twigs stout, tomentose, pubescence often persisting through third season. Portion of leaf scar below bundle scars sometimes dull red. Bark of twig immediately below leaf scar often brick-red. Inner bark shiny brick-red.

2. **Fraxinus biltmoreana** Beadle. Plate 87, Fig. 2.

Terminal bud apiculate, usually broader than long, flanked; three pairs of keeled scales, villose, light rusty-brown to dark brown, outer pair shorter than inner and often truncate. Lateral buds rounded, scurfy-pubescent. Leaf scars obcordate to semicircular, at thirty to forty-five degree angle with twig, upper edge hirsute, protruding slightly. Twigs stout, tomentose. Inner bark shiny brick-red.

3. **Fraxinus profunda** Bush. Plate 87, Fig. 3.

Terminal bud obtuse, ovoid, always flanked; three pairs of scales covered with heavy scurfy pubescence, dark brown, outer pair slightly longer than inner and often truncate to form apical notch. Lateral buds small, rounded. Leaf scars oblong, obconic, at ten to thirty degree angle with twig, upper edge protruding slightly, surface of scar often ridged due to raised bundle scars. Twigs stout, sparsely tomentose, pubescence usually not persisting after the first year. Inner bark shiny brick-red.

4. **Fraxinus oregona** Nutt. Plate 87, Fig. 4.

Terminal bud obtuse, apiculate, about as broad as long, always flanked; four pairs of scales, outer pair as long as inner, scurfy-pubescent. Lateral buds rounded, scurfy-pubescent. Leaf scars semi-orbicular to crescent-shaped, at forty-five degree angle with twig, upper edge wavy, protruding slightly. Twigs stout, unevenly tomentose. Pubescence heaviest at the node. Bark of twig greyish green beneath pubescence. Inner bark brick-red to light buff.

5. **Fraxinus pennsylvanica** var. **lanceolata** Sarg. Plate 87, Fig. 5.

Terminal bud acute, always flanked; three pairs of scales, outer pair sometimes truncate, rufous-tomentose, brown to black. Lateral buds rounded or angular. Leaf scars semicircular, usually nearly parallel with twig, upper edge protruding. Twigs stout, ashy grey. Bark of twig below leaf scars sometimes brick-red. Inner bark shiny brick-red.

6. **Fraxinus americana** L. Plate 87, Figs. 6 & 7.

Terminal bud obtuse, ovoid, always flanked; three to four pairs of scales, scurfy-puberulous, brown to nearly black, broader than long, outer pair of scales shorter than inner pairs. Lateral buds rounded, often superposed on vigorous shoots. Leaf scars semiorbicular or crescent-shaped at forty-five degree angle with twig. Twigs stout, glabrous, often spotted with glaucous bloom. Inner bark shiny brick-red.

7. **Fraxinus texensis** Sarg. Plate 87, Fig. 8.

Terminal bud obtuse, ovoid, always flanked; three pairs of scales, minutely puberulous, light rusty-brown to dark brown, broader than long, outer pair shorter than inner and often truncated. Lateral buds flattened. Leaf scars semiorbicular to crescent-shaped, at forty-five degree angle with twig, upper edge protruding slightly. Twigs moderately stout, glabrous, often spotted with bloom. Inner bark shiny brick-red.

8. **Fraxinus syriaca** Boiss. Plate 88, Fig. 9.

Terminal bud acute, flanked or nearly so; scales whorled, those of outer whorl foliar and thickened on back, dark brown, slightly puberulous, hairy at tip. Lateral buds rounded. Leaf scars semiorbicular, whorled, small, dark colored, upper edge not protruding, at forty-five degree angle with twig, elevated. Twigs stout, glabrous, shiny green. Inner bark light buff.

9. **Fraxinus potamophila** Herd. Plate 88, Fig. 10.

Terminal bud acute, always flanked; outer scales with foliar tip, thickened on back, slightly puberulous, dark brown. Lateral buds small, rounded to angular. Leaf scars semicircular, small, dark colored, at forty-five degree angle with twig, elevated, upper edge not protruding. Twigs stout, dark grey-brown and glabrous. Bark often light tan around rim of leaf scars. Inner bark light buff.

10. **Fraxinus quadrangulata** Michx. Plate 88, Fig. 11.

Terminal bud acute, always flanked; three pairs of scales, outer pair longer than inner, keeled on back, tip of outer pair usually decidedly foliar, hoary-tomentose pubescence, light buff. Lateral buds rounded to somewhat flattened. Leaf scars semiorbicular to crescent-shaped, more or less flattened on lower edge, at forty-five degree angle with twig, upper edge protruding very slightly. Twigs stout, more or less four-angled between the node. Pubescence short, rufous, heaviest at the nodes. Inner bark light buff. Lenticels often grouped beneath the leaf scars.

11. **Fraxinus mandshurica** Rupr. Plate 88, Fig. 12.

Terminal bud acute, always flanked; three pairs of scales, outer pair usually foliar, second pair occasionally so, dark brown, minutely puberulous, lateral buds angular, divergent. Leaf scars crescent-shaped, at forty-five degree angle with twig, elevated, upper edge hairy, protruding. Twigs often slender, flattened at nodes causing twig to have somewhat quadrangular internodes, glabrous. Inner bark light buff.

12. **Fraxinus holotricha** Koehne. Plate 88, Fig. 13.

Terminal bud acute, always flanked, usually at 90 degree angle with twig; three pairs of scales, outer pair with foliar tips, first and second pairs decidedly thickened on back and wooly along the side, dark brown. Lateral buds angular. Leaf scars semicircular, at ten degree angle with twig, upper edge protruding and hairy. Twigs slender, villous-tomentose. Inner bark light buff.

13. **Fraxinus oxycarpa** Willd. Plate 88, Fig. 14.

Terminal bud acute, always flanked; usually two pairs of scales, the outer pair foliar and longer than inner pairs, thickened on back, dark brown, slightly puberulous. Lateral buds small, rounded to somewhat angular. Leaf scars semicircular, thirty degree angle with twig, slightly elevated, upper edge protruding. Twigs often slender, flattened at nodes, glabrous. Inner bark light buff.

14. **Fraxinus excelsior** L. Plate 88, Fig. 15

Terminal bud obtuse, ovoid, always flanked; three pairs of scales, the outer pair about as long as the inner and having a more or less foliar tip, slightly puberulous, nearly black. Lateral buds rounded, sometimes with scattered, silky pubescence on the outer side. Leaf scars semicircular to semiorbicular, elevated, upper edge noticeably protruding. Twigs, stout, glabrous. Inner bark light buff.

15. **Fraxinus nigra** Marsh. Plate 88, Fig. 16.

Terminal bud acute, always solitary; three pairs of scales, the outer pair more or less foliar at the tip, thickened on back, dark brown, puberulous. Lateral buds small. Leaf scars orbicular, concave when viewed from the side due to the protruding upper edge, from nearly parallel to ten degree angle with twig. Bundle scars conspicuous. Twigs stout, glabrous except for small dots of scurfy pubescence just below the terminal bud. Inner bark light buff.

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EXPLANATION OF THE PLATES.

Plates 87 and 88

Terminal and lateral buds of *Fraxinus* ($\times 3$). Taken with a micro-tessar lens under approximately equal magnification and illumination.

Plate 87. Species of § Melioides: 1, *F. pennsylvanica*; 2, *F. biltmoreana*; 3, *F. profunda*; 4, *F. oregona*; 5, *F. pennsylvanica* var. *lanceolata*; 6, *F. americana* (whorled); 7, *F. americana*; 8, *F. texensis*.

Plate 88. Species of § Bumelioides: 9, *F. syriaca*; 10, *F. potamo-philis*; 11, *F. quadrangulata*; 12, *F. mandshurica*; 13, *F. holotricha*; 14, *F. oxycarpa*; 15, *F. excelsior*; 16, *F. nigra*.

Plate 89

Variation in *Fraxinus* twigs. Collections of the same species from various points.

Nos. 1 to 5, *F. americana*; 1, St. Louis, Missouri; 2, Indiana; 3, Granville, Mass.; 4, Norwich, Vt.; 5, Arnold Arboretum.

Nos. 6 to 8, *F. pennsylvanica* var. *lanceolata*; 6, Indiana; 7, Indiana; 8, Arnold Arboretum.

Nos. 9 & 10, *F. profunda*; 9, Arnold Arboretum; 10, Indiana.

Nos. 11 & 12, *F. quadrangulata*; 11, St. Louis, Missouri; 12, Indiana.

Nos. 13 & 14, *F. pennsylvanica*; 13, Dedham, Mass.; 14, Newton, Mass.

Nos. 15 & 16, *F. nigra*; 15, Petersham, Mass.; 16, Hanover, N. H.

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